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CENTRAL INTELLIGENCE AGENCY

INFORMATION REPORT

25X1A

[redacted]

COUNTRY China

SUBJECT Kuan Ting Detention Reservoir Project

PLACE ACQUIRED (BY SOURCE) - - -

25X1A

DATE ACQUIRED (BY SOURCE) [redacted]

DATE (OF INFO.)

DATE DISTR. 11 May 1954

NO. OF PAGES 6

NO. OF ENCLS.

SUPP. TO REPORT NO.

THIS IS UNEVALUATED INFORMATION

25X1X

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1. The Yung Ting Ho, which is the largest river in North China north of the Yellow River, has been the cause of great catastrophe for centuries. It has a maximum discharge of over five thousand cubic metres per second in the flood period, which far exceeds its carrying capacity. Dyke breaches occur quite frequently along the middle and the lower reaches of the river, inundating thousands of square kilometres of fertile farm land on the Hopei plain. The Yung Ting Ho also carries an enormous amount of silt in flood, which is drained and deposited in the Hai Ho. The navigability of the Hai Ho thus deteriorates and the prosperity of the port of Tientsin is greatly threatened.

2. In order to solve the two-fold problem of regulating the flood flow to relieve the suffering of the farmers of the Yung Ting Ho valley and of disposing of the silt to ameliorate the silting of the Hai Ho, the North China River Commission (predecessor of North China Conservancy Bureau) formulated a radical improvement scheme for the Ung Ting Ho. One of the principal flood control works of the scheme is the construction of the Kuan Ting detention reservoir, the function of which is to smooth out the flood peaks so as to lessen the menace of inundation and incidentally to reduce the erosion of the river bed as well as the loose cliffs.

3. The Yung Ting Ho has three main tributaries, the Sang Kan Ho and the Yang Ho unite at Chu Kuan Tun to form the Yung Ting Ho, flowing south-east to Sze Chia Tsai where the Wei Shui Ho joins it. About three kilometres below the confluence, the river enters a rocky gorge near

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the village of Kuan Ting. It is proposed to construct a detention reservoir in the combined flood valley of the Yung Ting Ho and Wei Shui Ho by building a masonry dam across the upper end of the Kuan Ting gorge. The proposed detention reservoir has the shape of a funnel. It commands a very wide valley until Kuan Ting is reached, which resembles the throat of the funnel. At elevation 469 m. T. D., it is nine kilometres long north and south and 3.6 kilometres wide east and west near Yang Ta Jen Chuan, but only 106 metres wide at the dam site. It has a storage capacity of 330 million cubic metres up to the crest of the spillway (elevation 466 m. T. D.), which will reduce the flood peak of 5,700 (as that of 1924) to 1,200 cubic metres per second. The areas and storage capacities of the Kuan Ting detention reservoir for different elevations are listed below:

Elevation	Area	Storage Capacity
(m.T.D.)	(sq.km.)	(10^6 m^3)
450	1.8	2
452	3.1	6
454	6.5	16
456	13.1	37
458	21.0	66
460	27.2	115
462	32.7	172
464	37.8	241
466	42.2	325
468	46.0	417
469	47.6	460

4. The rock at the dam site is blue limestone of excellent quality. The seams dip upstream, making an angle of approximately 25 degrees with the horizontal. There is no indication of any faulting near the dam site. The cliffs on both sides of the gorge are nearly perpendicular for 20 to 30 metres above the river bed and then start to recede. The average width of the gorge is 70 to 90 metres wide at the bottom. Both the topographical and the geological conditions are, therefore, very favorable for a dam site. From the result of the borings, drilled in 1935-6, it is found that rock stratum reaches a depth of 23.17 metres beneath the river bed at the deepest part of the valley floor.

5. The general features of the Kuan Ting detention reservoir comprise a gravity spillway dam across the gorge and a side tunnel through the right cliff serving as the outlet of the reservoir, and also as a stream diversion tunnel during the time of construction. At ordinary floods, the outlet tunnel alone will be quite effective to iron out the flood peak and to discharge safely below the dam. The spillway will be operative only during the maximum flood. The Kuan Ting detention reservoir will undoubtedly be subject to some silting, as the Yung Ting Ho carries an enormous percentage of silt in time of flood. From careful computations, taking into account all the available data concerning the Yung Ting Ho silt, it is found that the Kuan Ting detention reservoir will be effective for about three hundred years. Assuming a conservative value of 30 per cent of silting of the reservoir, its flood control effect is indicated as follows:

Maximum inflow (m^3/sec.)	Total inflow (10^6 m^3)	Water Level (m.T.D.)	Depth of Water Behind Dam (meters)	Maximum outflow (m^3/sec.)	Storage ($10^6 m^3$)
8,000 (estimated Max)	670	469.0	29.5	2,320	314.7
5,700 (1924 flood)	488	464.2	29.7	1,200	176.7
4,000		461.3	21.8	1,110	107.2
3,000		459.2	19.7	1,050	66.6
2,000		456.9	17.4	970	34.5
1,200 (1929 flood)	234	454.4	13.5	870	10.6

6. The cross-section of Kuan Ting dam is designed according to Creager's method. The elevation of the crest is assumed at 466.0 m.T.D. After the cross-section of dam is determined, the top height of two metres is changed into a movable drum gate. The design data are listed below:

	m.T.D.
(1) Maximum flood level	469.0
(2) Elevation of the dam crest	466.0
(3) Elevation of the river bed	439.0
(4) Elevation of the deepest rock bed	419.0
(5) Elevation of the upstream silt deposit (assumed)	452.5
(6) Elevation of the downstream silt deposit	439.0
(7) Unit weight of masonry	2,320 kg/m^3 (145 lb/ft^3)
(8) Unit weight of water	1,000 kg/m^3 (62.5 lb/ft^3)

(9) Maximum allowable vertical stress of the foundation:
 (a) Upstream . . . . . . 9.76 kg/cm^2 (20,000 lb/ft^2)
 (b) Downstream . . . . . 7.82 kg/cm^2 (16,000 lb/ft^2)

(10) Maximum allowable inclined stress of the foundation . . . 14.63 kg/cm^2 (30,000 lb/ft^2)

(11) Area subjected to uplift force of the foundation and horizontal plane of dam . . . 50%

(12) Coefficient of friction . . . 0.60

7. In computing the stress of the dam section it is assumed that the uplift force and the pressure of silt do not act at the same time. The greater influence between the two is considered as effective. After the dam section is fixed, sections of the Madden dam constructed by the Bureau of Panama Canal, USA and of the Norris dam constructed by the Tennessee Valley Authority, USA are selected for a comparative study in order to insure security. Those two dams were designed and tested carefully before construction and are in excellent operation. Superimposed sections according to the high flood levels of the three dams are plotted and compared. It is observed that the section of the Kuan Ting dam is very suitable.

8. The movable gate over the crest is a steel drum gate. It is divided into six bays with each bay 13.5 metres in width. Its type is according to the standards of the US Bureau of Reclamation. The pool under the gate leads to the upstream and the downstream ends by an inlet culvert and an outlet culvert respectively. In lifting the drum gate, the inlet culvert is opened and the outlet culvert closed. Water flows into the pool and the gate is lifted by the buoyant force. In lowering the gate, the inlet culvert is closed by its own weight. The time for lifting or lowering takes only a few minutes.

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9. A reinforced concrete bridge is constructed over the dam crest. It is also divided into six bays. Each bay has a span 13.5 metres and the width of each pier is 1.8 metres. The bottom of the bridge is one metre higher than the highest flood level. Machinery for operating the inlet culvert is to be placed on the upstream platform of the bridge and that for the outlet on the downstream ends of piers. The design load for the slabs and the girders of the concrete bridge is 488 kg/m^2 (100 lb/ft^2).

10. The energy-dissipation structure below the dam consists of the 18-metre wide talus from the base of the dam. Its upper end is three metres lower than the river bed and has a width of 8.6 metres from the base of the dam. It then slopes upward to the elevation of the river bed. At the end of the slope, the first row of dented sill is to be constructed with a second row of dented sill at its end. Both of these two rows of sills have a height of 1.0 metre and width of 2.5 metres. Under the second row of sill steel sheet piles should be driven down to 10 metres below the river bed. Downstream from the talus riprap in wire cages is to be placed with a width of 20 metres.

11. The main body of the dam is to be constructed of cyclopean concrete, i.e., 1:3:6 concrete with 30 per cent rubble, in order to reduce the cost of construction. For the dented sills and both faces of the dam which are contiguous to the flowing water, 1:1-1/2:3 concrete is to be placed in order to protect it against erosion and to decrease the seepage. Cyclopean concrete is also to be applied to the piers. The slabs and the girders of the bridge are to be constructed of 1:2:4 reinforced concrete. Drum gates, valves for intake and outlet culverts, and the operating machinery are still to be constructed of steel. On the upstream and downstream ends of the base of the dam, concrete cut-off walls are to be cast monolithically with the dam down to a depth of five metres into the rock. The body of the dam is also to be keyed into the rocks of the two banks for three metres.

A side tunnel is to be driven through the right cliff of the gorge serving as the outlet of the reservoir. The length of the tunnel is about four hundred metres and an open cut channel with a length of about 30 metres is attached at each end. The cross-section of the tunnel is of the horse-shoe type, with a diameter of 10 metres and a cross-sectional area of 82.9 sq. metres. The rate of discharge during the maximum flood is computed as follows.

Let H = total head.
V = mean velocity of the flowing water in the tunnel.
F = coefficient of friction.
L = length of the tunnel.
D = diameter of the tunnel.
Q = discharge of the tunnel.

$$H = 0.23\frac{V^2}{2g} + \frac{L}{D}\frac{V^2}{2g} + 0.78\frac{V^2}{2g}$$

$$25 = 0.23\frac{V^2}{2g} + 0.02\frac{400}{10}\frac{V^2}{2g} + 0.78\frac{V^2}{2g}$$

$V = 16.4$ m/sec.
$Q = 16.4 \times 82.9 = 1360$ m^3/sec.

13. The lining of the tunnel is to be constructed of 1:2:4 concrete with an average thickness of 30 centimetres. Downstream from the tunnel at the end of the open cut two rows of dented sills are also to be constructed. The tunnel is used as a stream diversion tunnel during the construction of the dam.

14. On each of the upstream and downstream sides of the dam site, a temporary cofferdam should be built. The upstream cofferdam has a top elevation of 448 m.T.D. and a top width of 6 metres with a fore slope of 2 to 1 and a back slope of 3 to 1. Beneath the toe of the fore slope, which is paved with stone, a row of 10 metre steel sheet piling shall be driven into the river bottom in order to reduce seepage. This steel sheet piling should later be pulled out and reused under the dented sills of the energy-dissipation structure of the main dam. In front of the steel sheet piling, riprap 10 metres wide and two metres thick shall be placed to prevent erosion. The top and the back slope of the cofferdam shall be built of rock and earth fill. The downstream cofferdam has a top elevation of 466 m.T.D. and of the same type of construction as that of the upstream cofferdam with the exception of the steel sheet and the riprap protection.

15. For the convenience of construction, a motor road is to be built from the Huai Lai station on the Peiping-Suiyuan Railway to the dam site, in order to transport materials and machineries. Offices and temporary camp buildings and material store houses should also be built at Huai Lai Hsien and near the dam site at Tou Ying, opposite bank of Kuan Ting.

16. The construction of Kuan Ting project is expected to be finished in three years:

1st Year--Construction of motor road, camp buildings and storehouses; purchase of machineries and tools for construction of diversion tunnel.

2nd Year--Construction of cofferdams; excavation of damsite; construction of lower portion of the dam.

3rd Year--Construction of the upper part of the dam, and the talus; construction of reinforced concrete bridge; erection of the movable drum gates and other steel works.

17. The land appropriation, the removal of villages and the construction of surrounding dykes are to be carried out simultaneously.

18. The cost estimate of the Kuan Ting project according to the pre-war (1937) price index is as follows:

Items	Total Sum
Motor road	$ 80,655
Bridges and culverts	61,330
Office building and storehouse	30,100
Outlet tunnels	517,890
Temporary cofferdam	71,080
Dam and its accessories	1,788,968
Steel gates and its accessories	169,200
Mechanical equipment	500,000
Construction equipment	250,000
Land appropriation	594,000
Removal of villages	116,000
Surrounding dikes	119,600
Overhead expenses	396,000
Contingency	775,177
Grand Total	$5,470,000

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19. The North China River Commission started to build the motor road approach to the dam site in 1937, preparatory to the construction of the diversion tunnel in 1938 and of the dam in 1939 to be finished in 1940. The Sino-Jap war broke out in July 1937, putting a complete stop to the construction work. The motor road was subsequently demolished during the war years. After V-J day the North China River Commission, re-established in Tientsin, petitioned the National Conservancy Commission to undertake the Kuan Ting project as one of the principal conservancy works in the realm of relief and rehabilitation. Afterwards, the UNRRA-CNRRA authorities became interested in the Kuan Ting project for which they promised to allocate some mechanical equipment and construction materials at their disposal as well as CNC $10,000,000,000 and 260 tons of flour. At the same time the Ministry of Water Conservancy (successor to the National Conservancy Commission) requested the Executive Yuan to appropriate CNC $30,000,000,000 as the first disbursement for the engineering expenses.

20. The North China Conservancy Bureau established an engineering bureau in Peiping in August 1947, to take charge of the construction of the Kuan Ting project. Unfortunately, due to the embargo of UNRRA supplies for North China, the mechanical equipment and construction materials were all impounded. The appropriation requested from the Executive Yuan has never materialized. With CNC $2,000,000,000 advanced by the Ministry of Water Conservancy, the engineering bureau for the construction of the Kuan Ting project succeeded in building the first stretch of the motor road approach to the dam site with macadam surface from Huai Lai station to the left bank of the Yuan Ting Ho, and in constructing a combined office and warehouse building at Huai Lai Hsien. Materials for the construction of the bridge across the Yung Ting Ho were purchased, and construction of the bridge was soon started. It was expected that the construction program would be much accelerated as soon as the UNRRA-CNRRA equipments and construction materials, of which the embargo had recently been lifted, were shipped north and the Executive Yuan had made some substantial appropriation for the project.

/Available on loan in the CIA Library is a photostat of Kuan Ting Dam--Location Plan and Dam Section/

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